Tropical deep convection, upper tropospheric humidity and OLR: Recent insights from GERB

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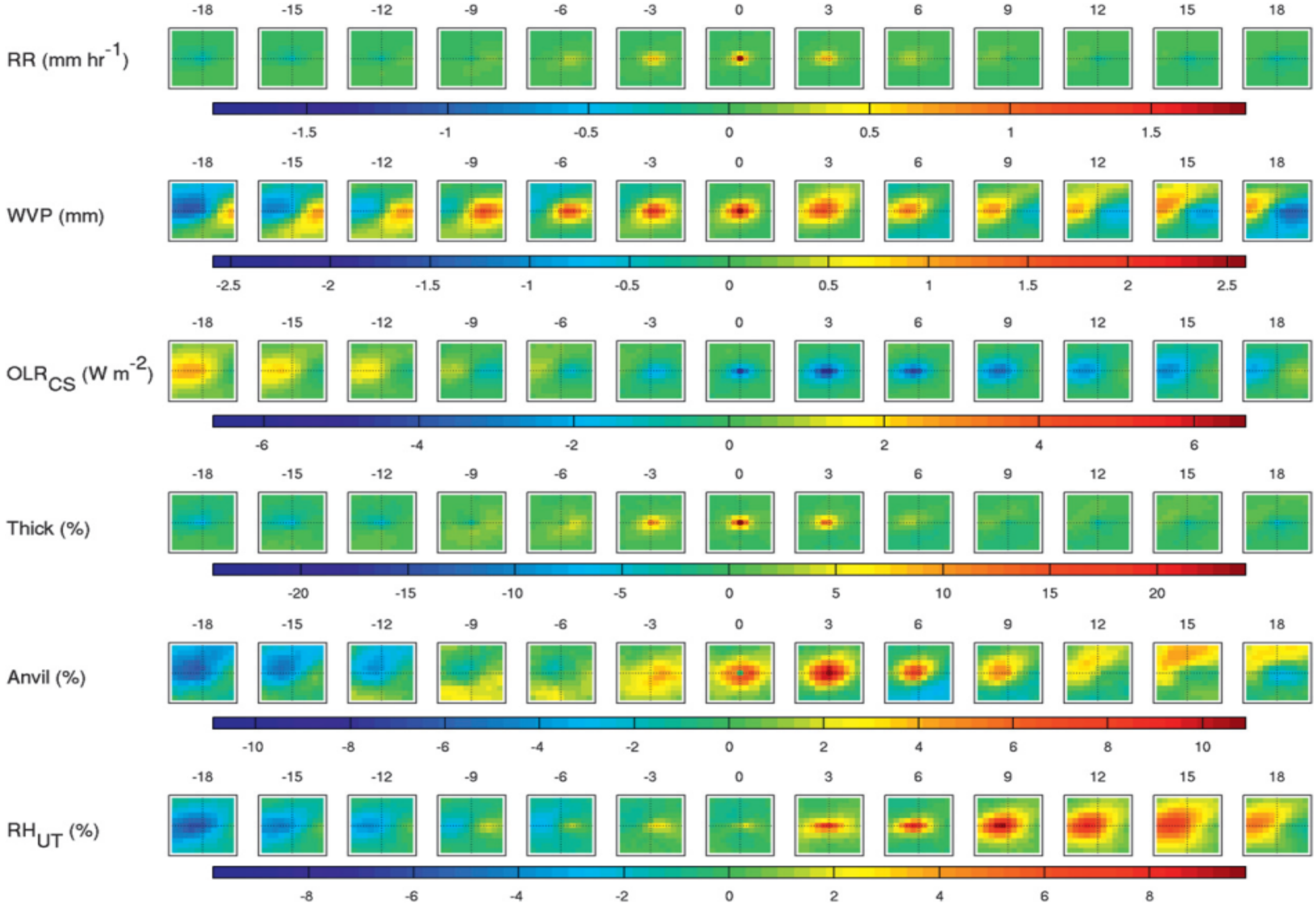
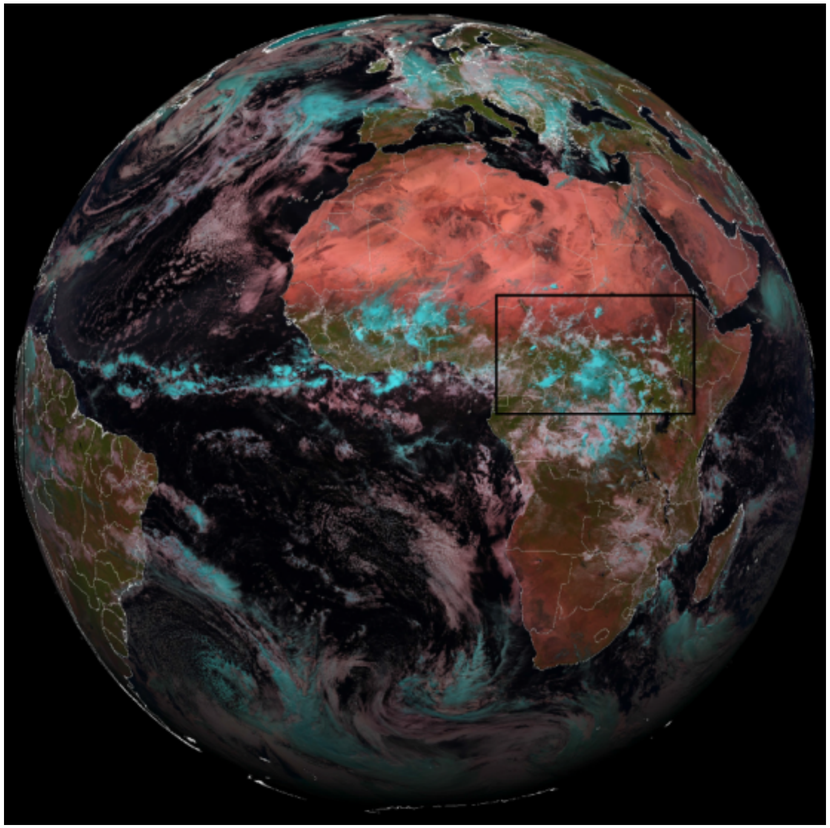
Motivation

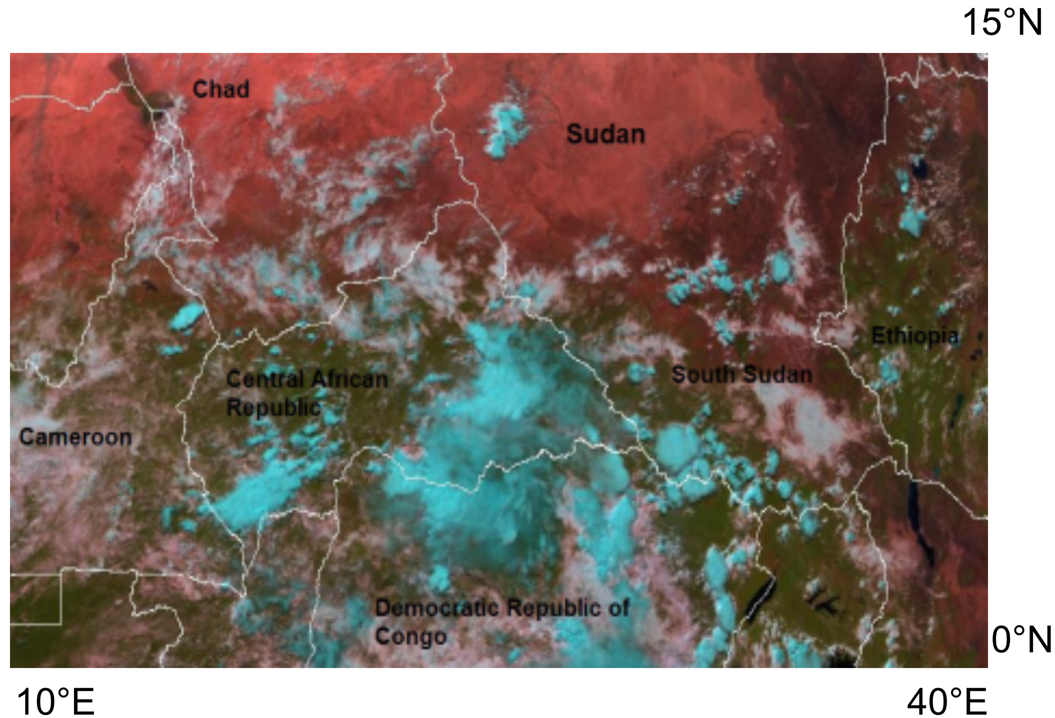
Zelinka and Hartmann, 2009
tropical Pacific, time composites
centred on intense convection



What are the temporal and spatial scales of the upper tropospheric humidity response to deep convection over tropical Africa and what are the associated impacts on (clear-sky) OLR?

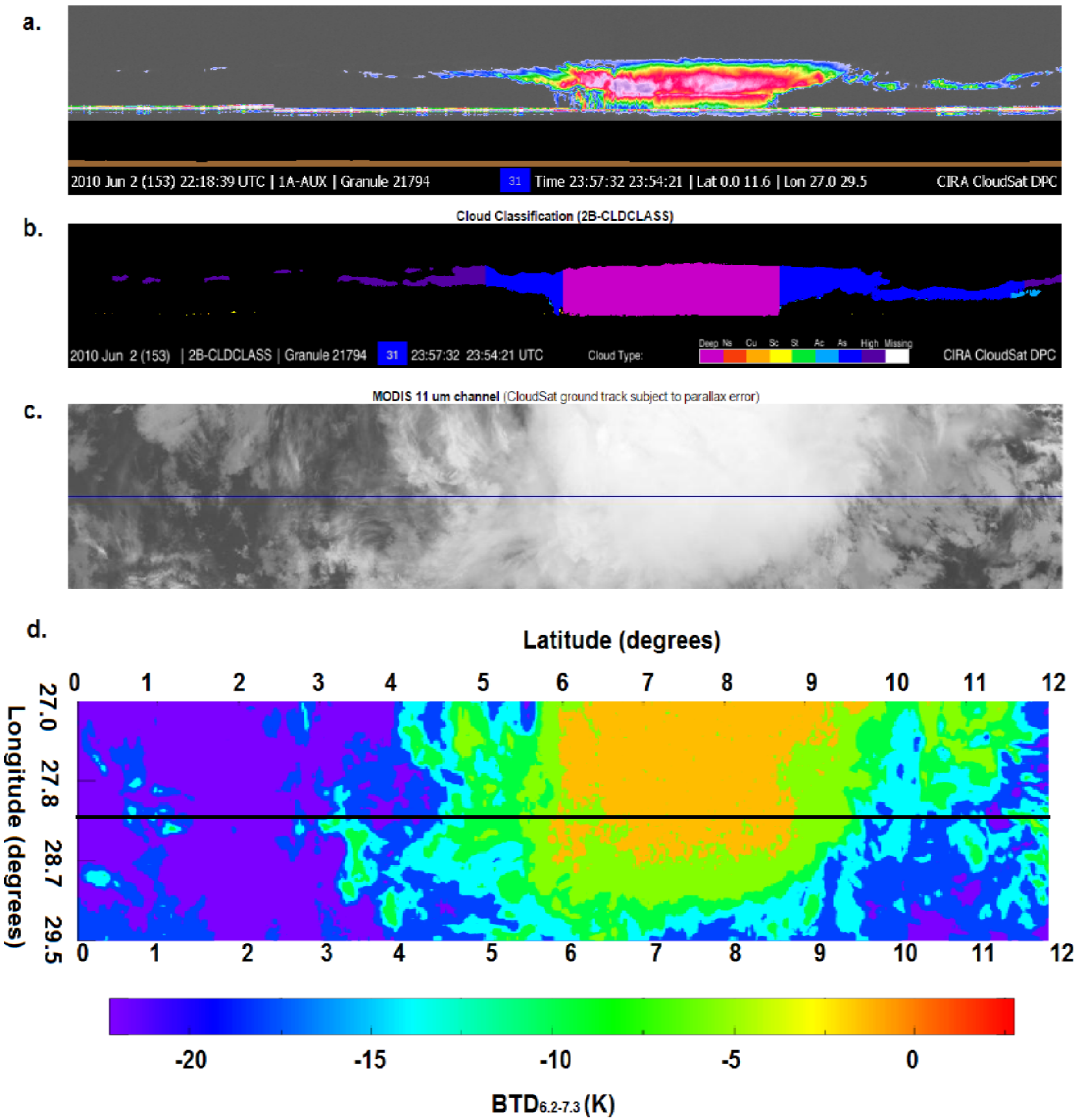
Motivation





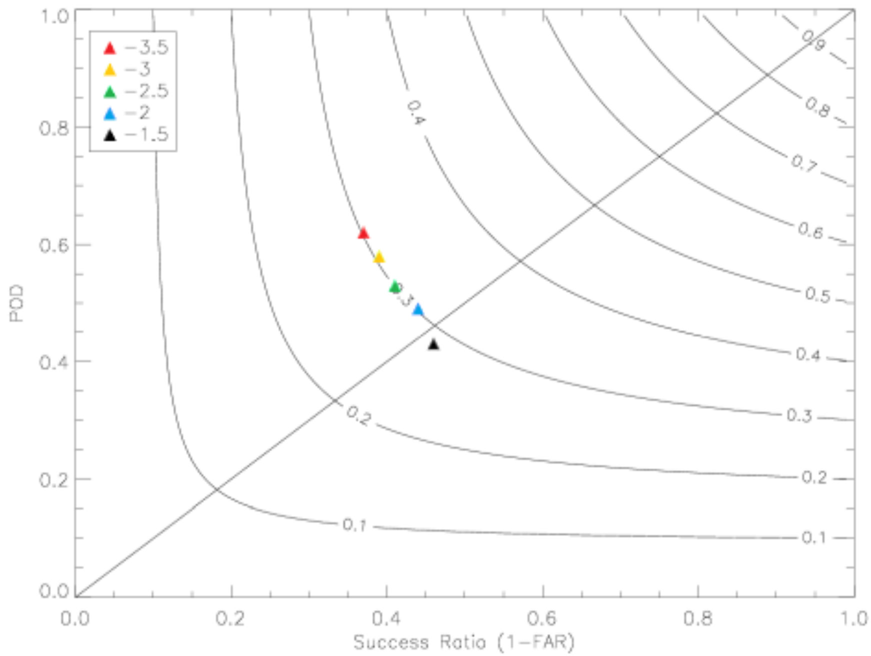
What are the temporal and spatial scales of the upper tropospheric humidity response to deep convection over tropical Africa and what are the associated impacts on (clear-sky) OLR?

Detecting deep convection

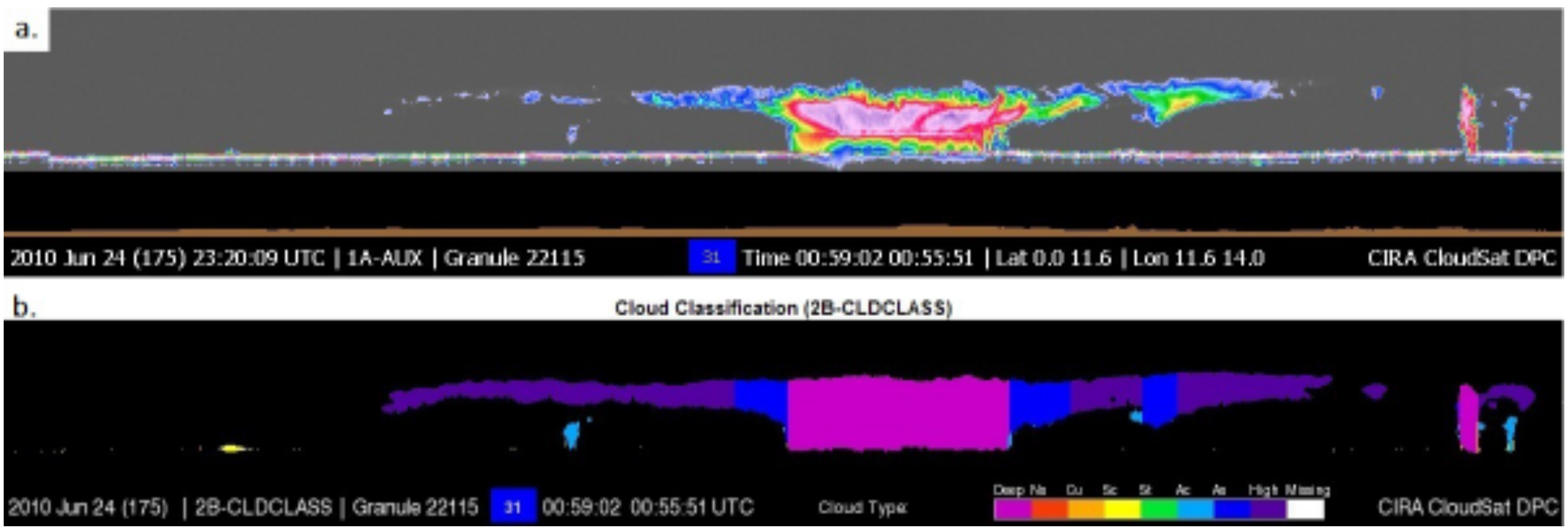


- Use simple 6.2-7.3 µm BTD threshold.
- Initial threshold estimates from RT modelling
- Tuned against co-located CloudSat classifications (2B-CLDCLASS (Sassen and Wang, 2008)) using ROC analysis
- Expect threshold variation with time of day and year

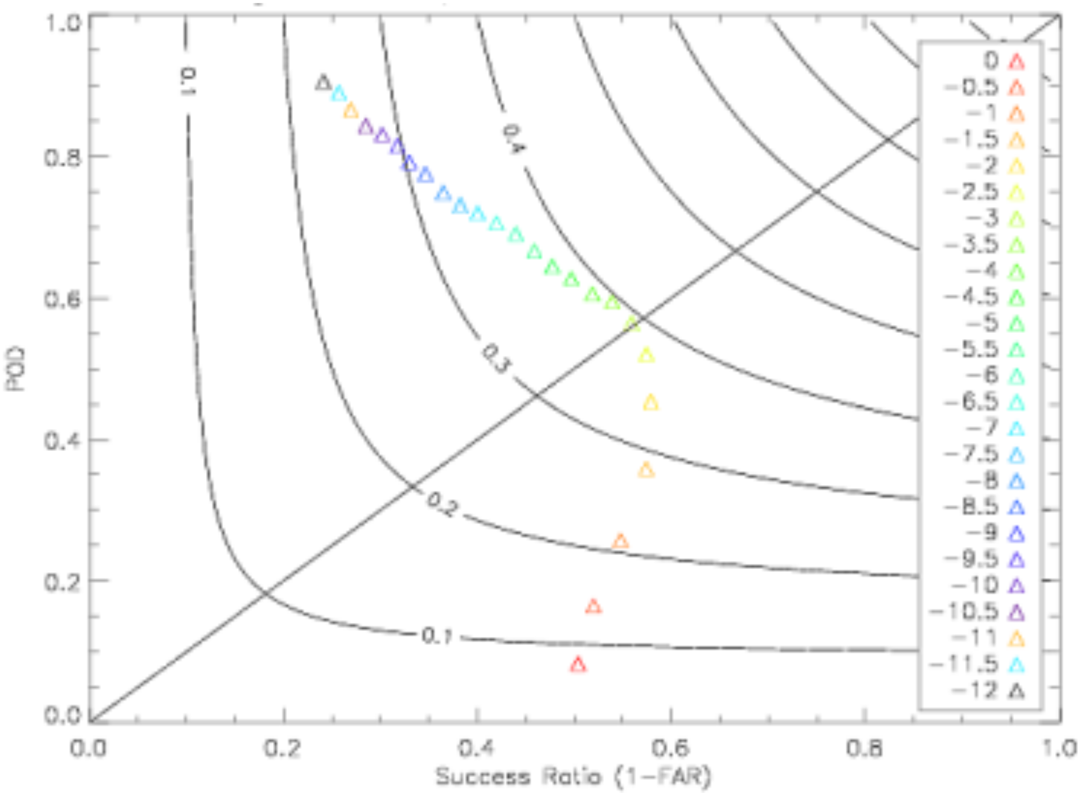
Detecting deep convection



- Initial analysis showed a high percentage of false alarms regardless of threshold chosen
- Issue with anvil altostratus: contiguous with deep convection but not classified as part of system
- Reclassification of contiguous altostratus within 1 cloud radii and depth > 5 km as 'deep convection'



Detecting deep convection



Example ROC analysis for June 2010 (night) using re-classified 2B-CLDCLASS data

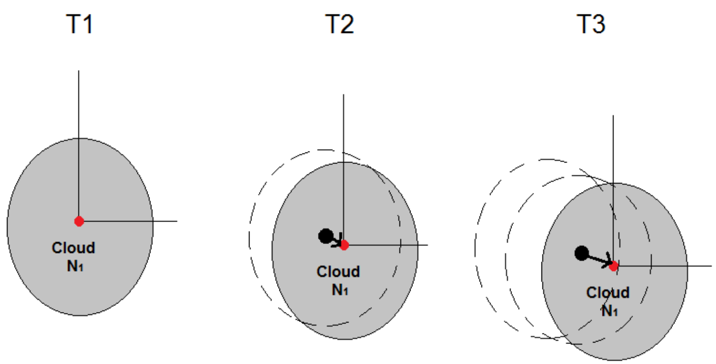
Similar methodology applied to detect anvil cirrus based on 12.0-10.8 μm BTD and 2B-CLDCLASS-Lidar cirrus classification

Month	June 2010		December 2010	
Time	Day (~1300 UTC)	Night (~0100 UTC)	Day (~1300 UTC)	Night (~0100 UTC)
6.2-7.3 μm threshold (>)	-9 K	-3 K	-3 K	-7 K
12.0-10.8 μm threshold (<)	-3 K	-1 K	-2.5 K	0 K

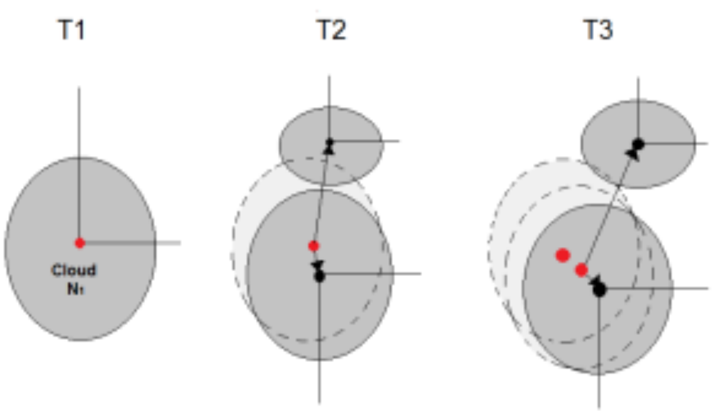
Tracking individual events

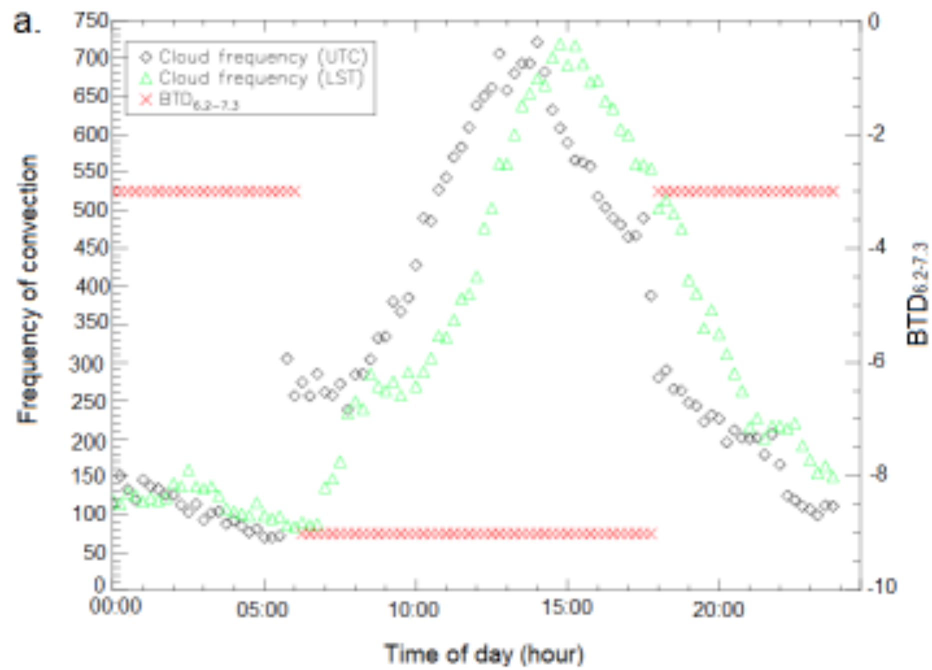
Tracking algorithm is relatively simple, combining tests for:

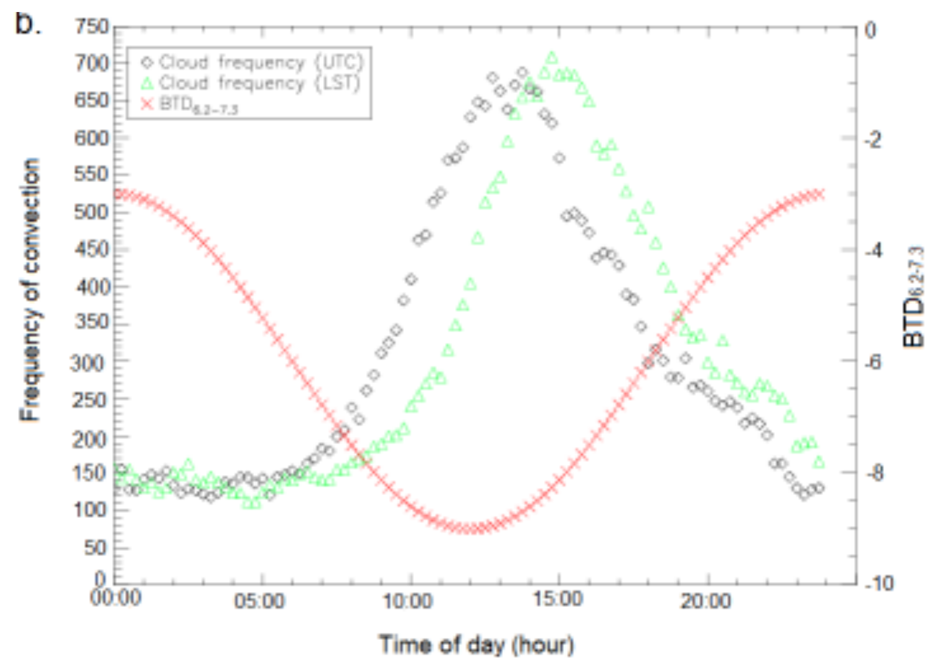
Area overlap and centre of mass displacement (Williams and Houze, 1987)



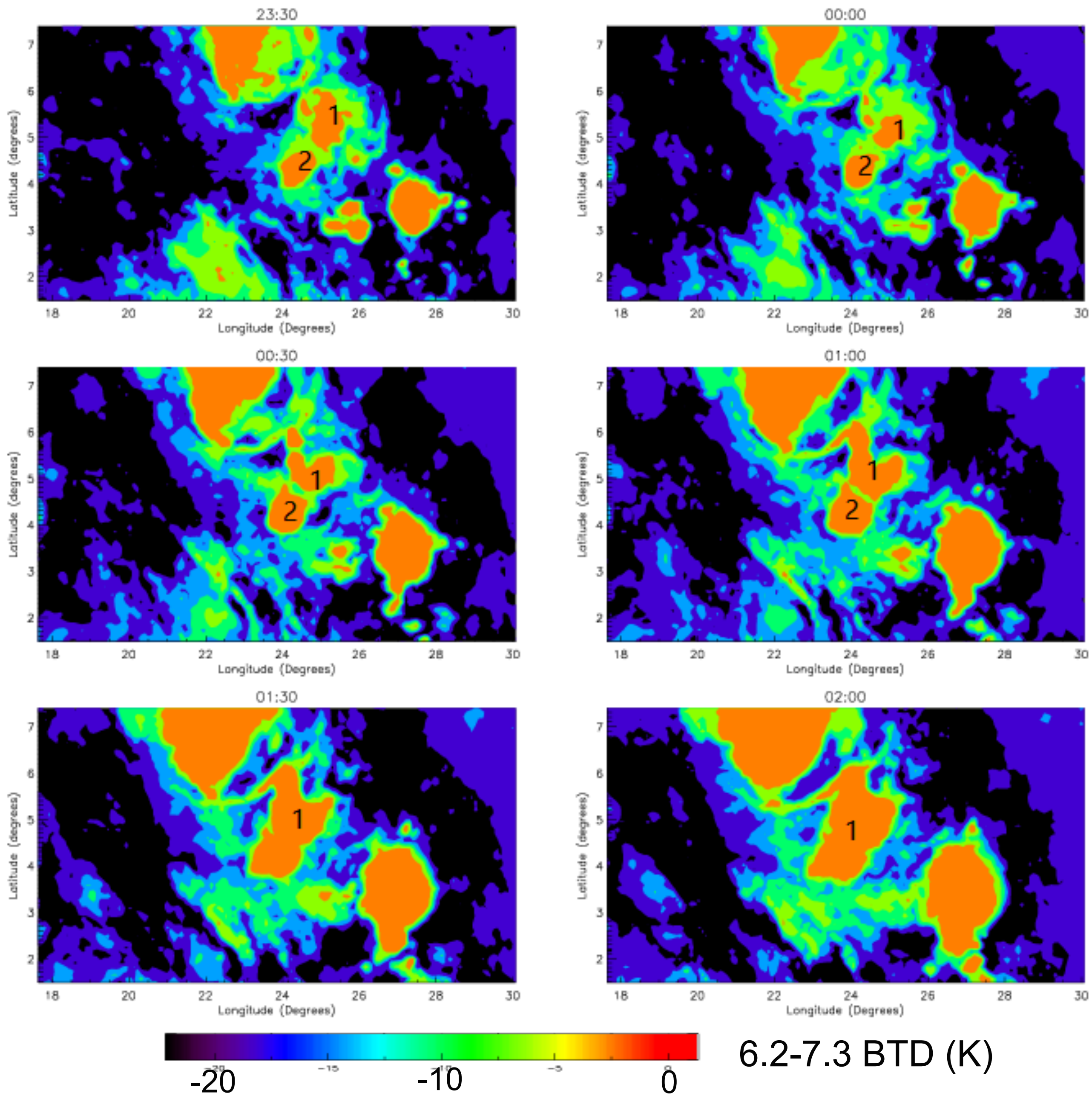
and splitting or merging





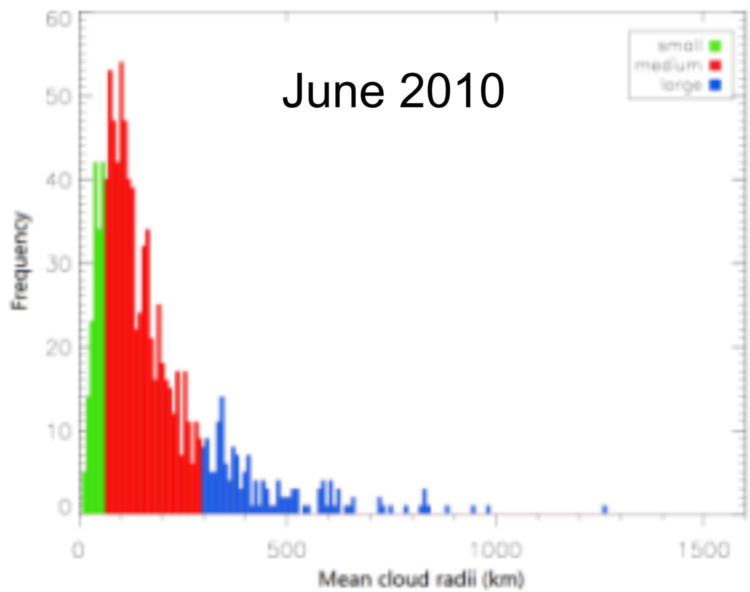


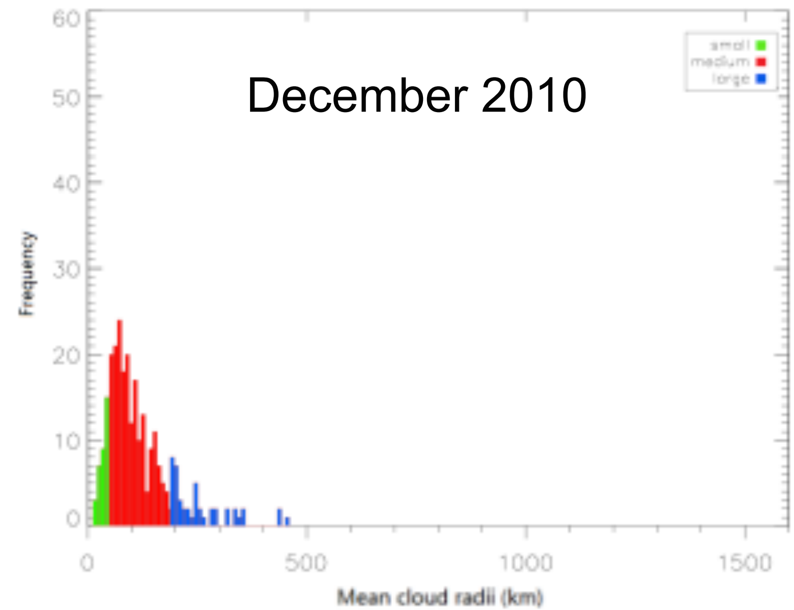
Tracking individual events

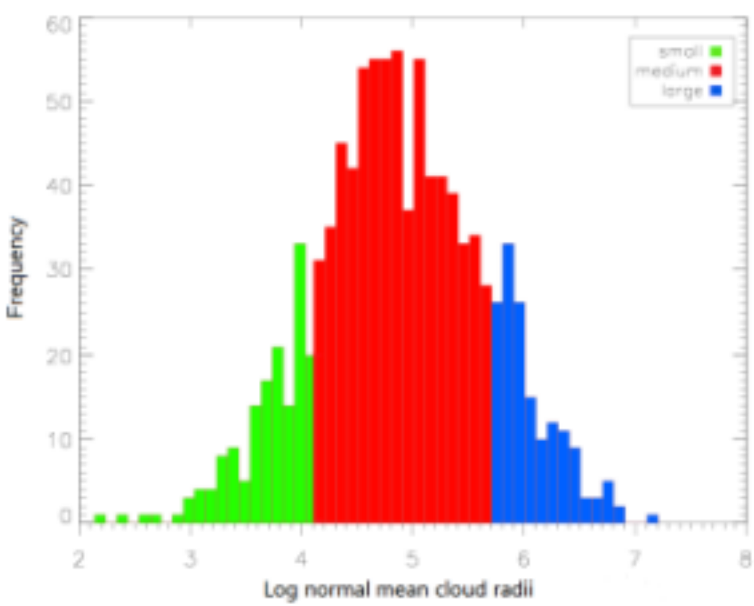


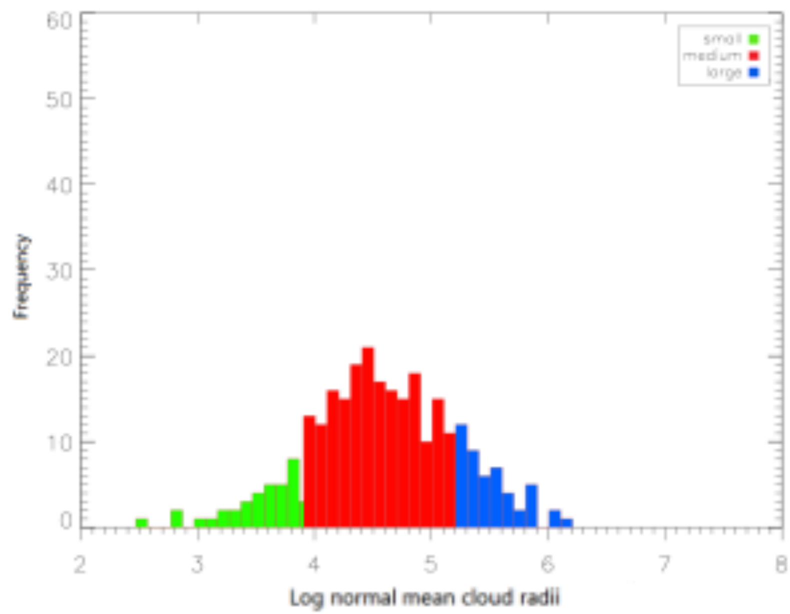
Example of tracking two clouds that merge (June 6th 2010)

Size/frequency distribution



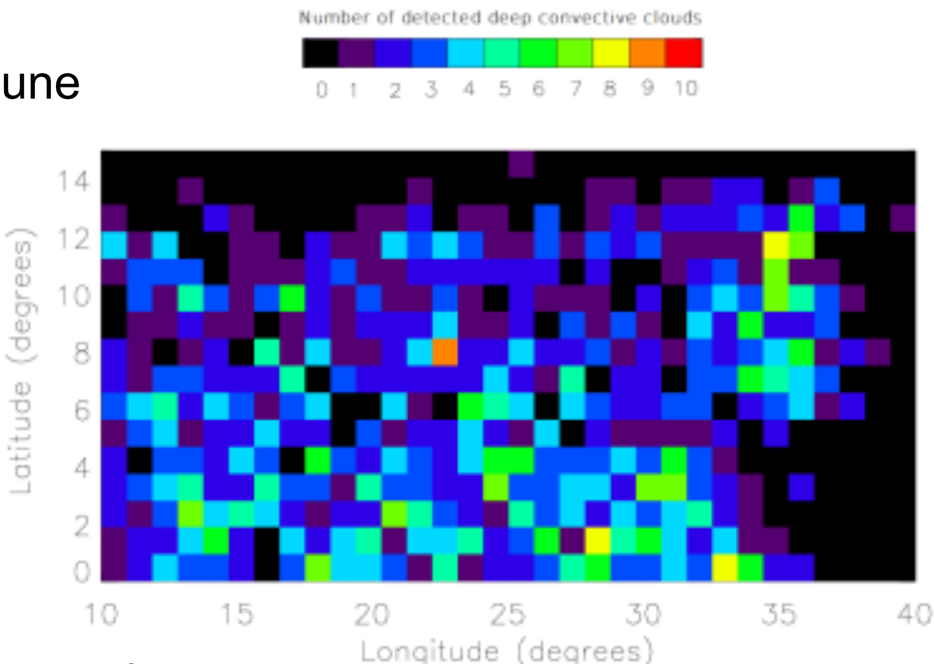






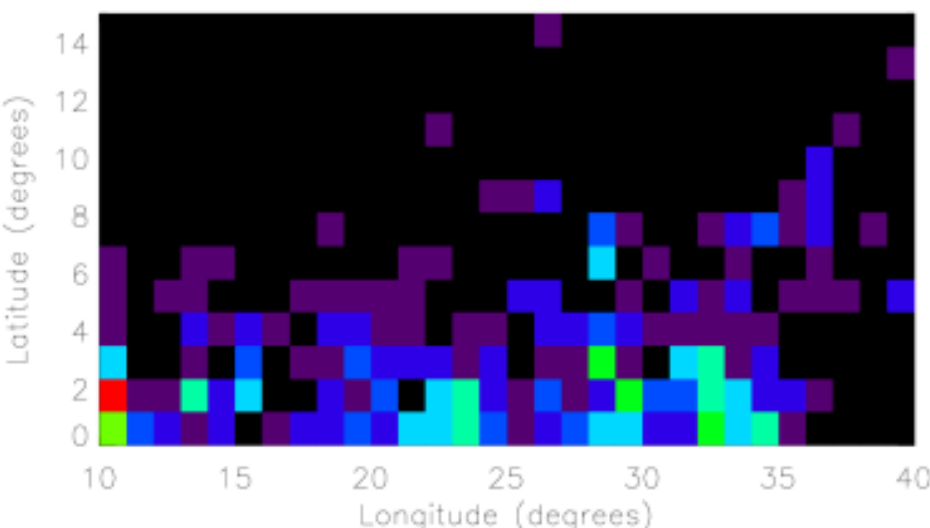
Geographical distribution

June

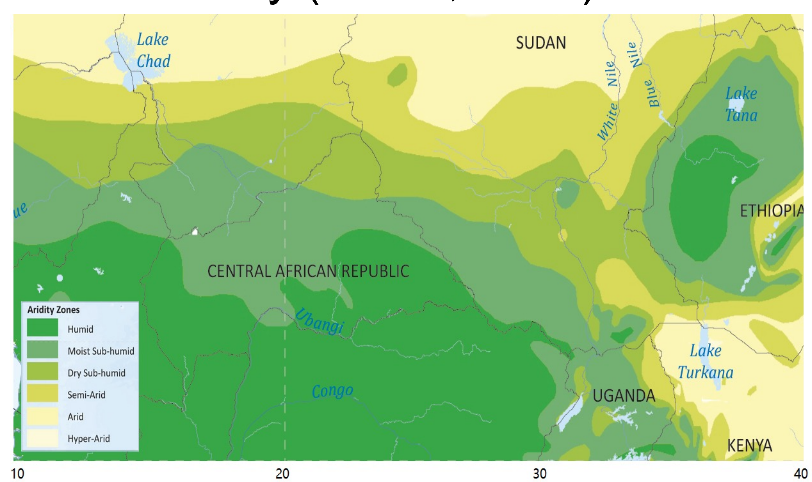


Relief (Berens, 2013)

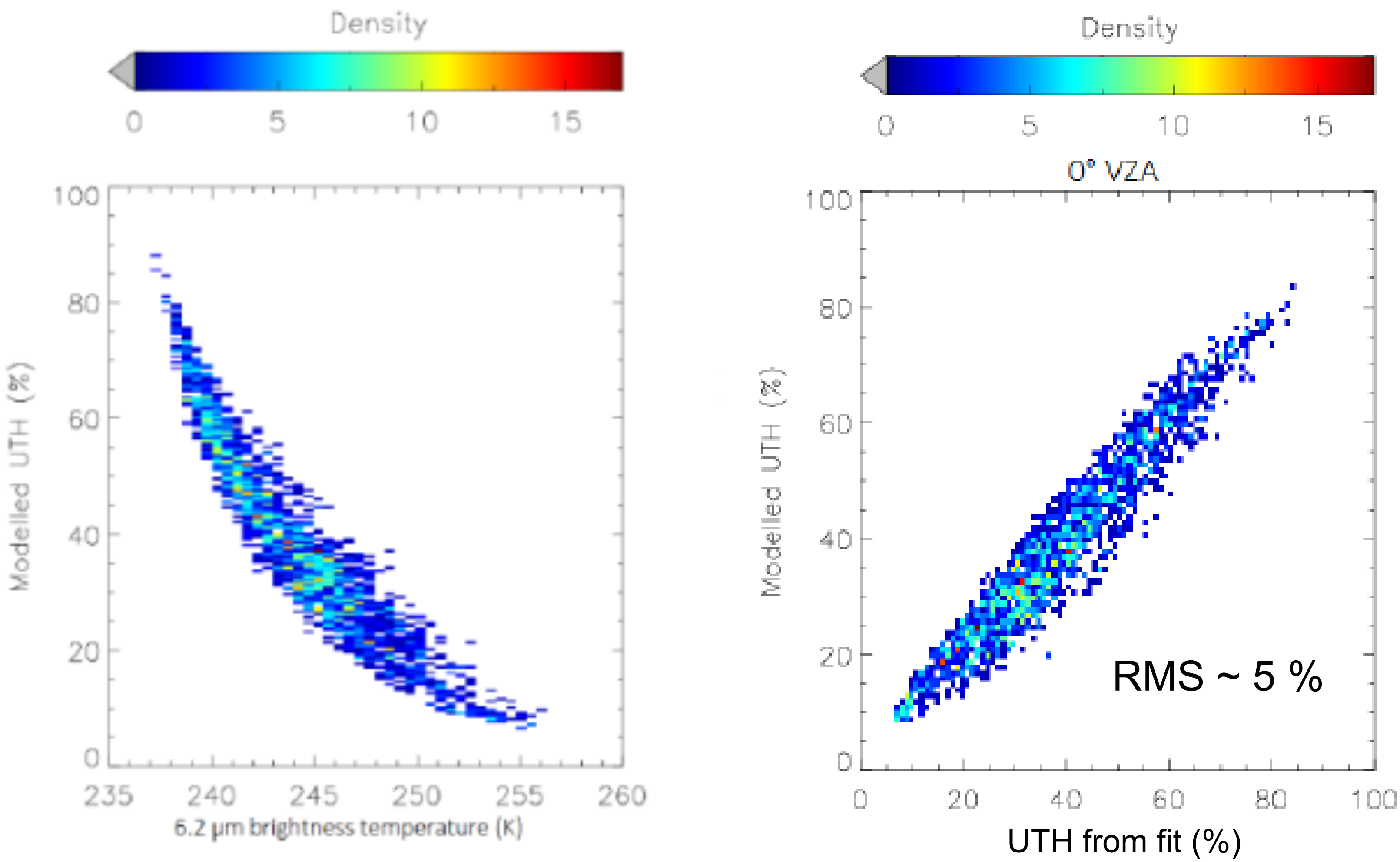
December



Aridity (UNEP, 2015)



Estimating clear –sky Upper Tropospheric Humidity

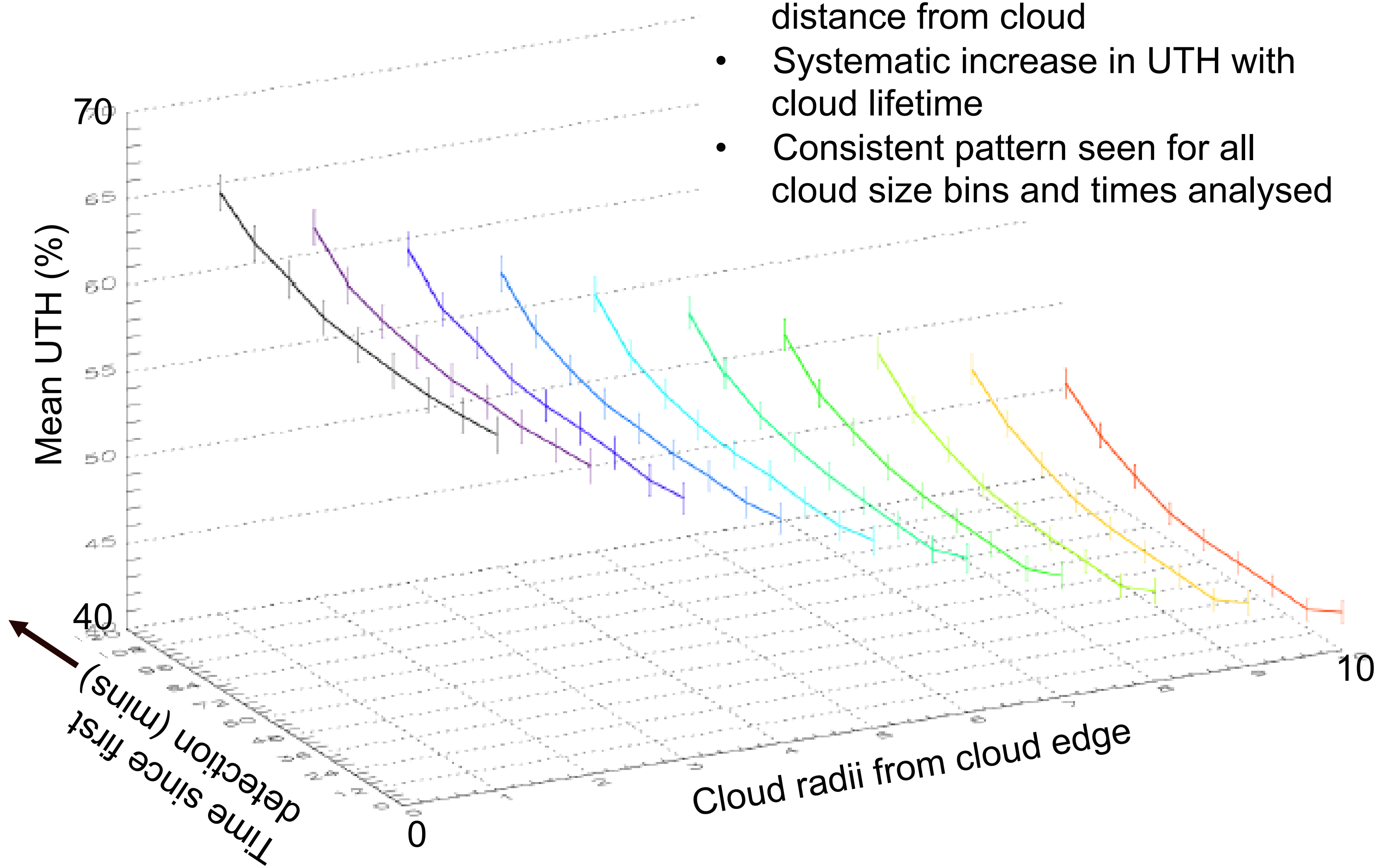


$$a + bTB_{6.2} = \ln\left(\frac{UTH * P'}{cos\theta}\right)$$

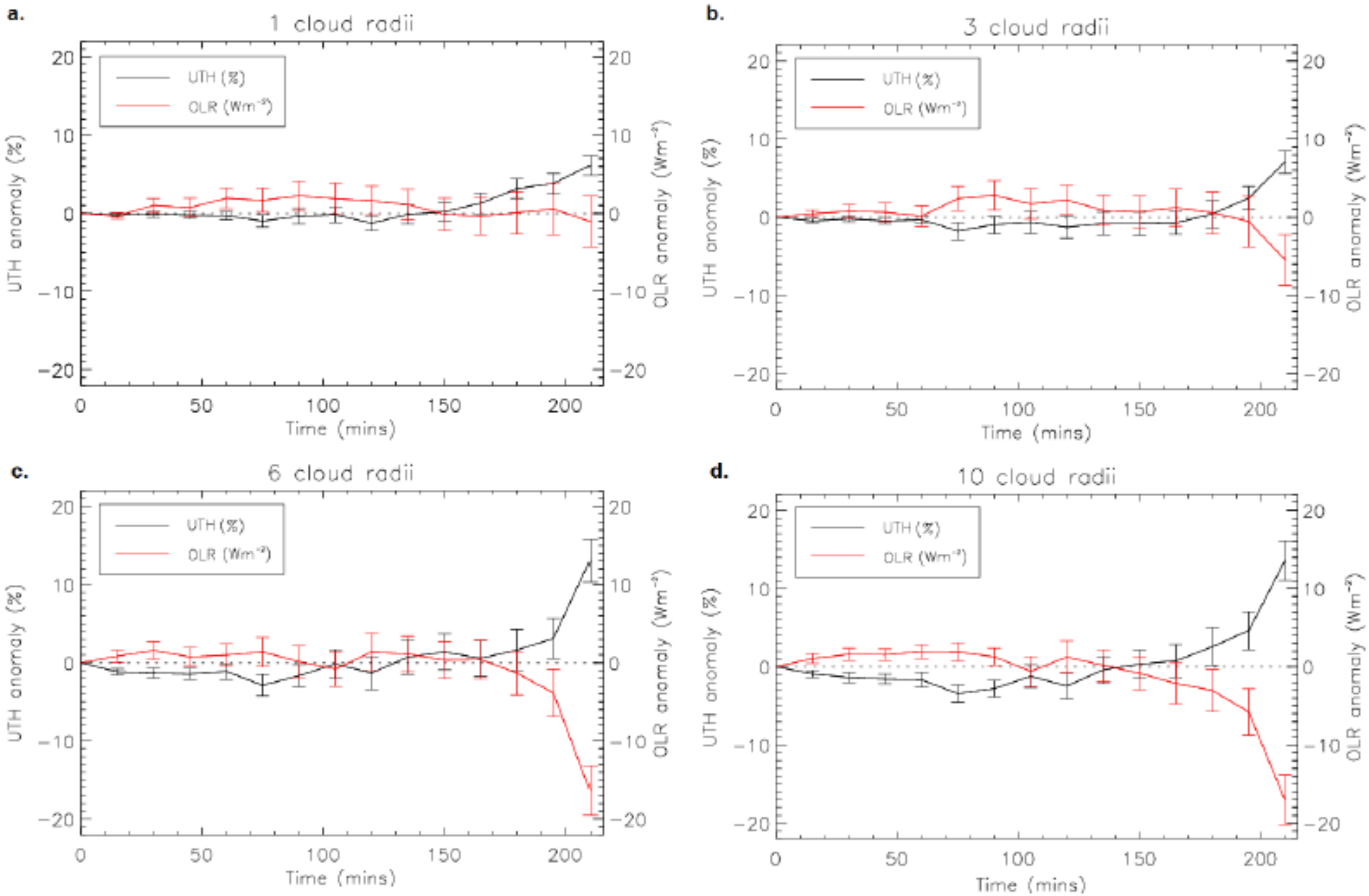
Soden and Bretherton, (1993)

Clear-sky UTH patterns (medium sized clouds)

- Systematic reduction in UTH with distance from cloud
- Systematic increase in UTH with cloud lifetime
- Consistent pattern seen for all cloud size bins and times analysed



Clear-sky UTH and OLR response



Anomalies relative to value at t=0, medium cloud size-bin

Summary

Method

- Simple method developed to detect, track and quantify impact of deep convection on UTH and OLR over tropical Africa
- Evaluation of detection method indicated need to re-classify CloudSat 2B-CLDCLASS anvil altostratus as part of deep convective system if within 1 cloud radii and > 5 km thick
- Detections during June and December 2010 show expected seasonal and geographical patterns

UTH/OLR response

- Magnitude of clear-sky UTH response to deep convection increases with distance from cloud edge
- Temporal response shows an initial drying followed by moistening for all cloud size bins
- Timing of peak response lags that of most intense convection by between 30 and 120 minutes dependent on cloud size and spatial region considered
- Clear-sky OLR response strongly anti-correlated to UTH: largest perturbations (-4.7 W m^{-2}/1 % UTH increase) seen in December due to drier base state of atmosphere